

Appl. No : 10/053241
Filed : January 16, 2002

AMENDMENTS TO THE CLAIMS

The claims as listed below will replace all prior listings and presentations of claims in the above-identified application.

Please cancel Claims 31, 32, 34 and 35 without prejudice.

Please amend Claims 3, 30 and 40-42, and add new Claims 43-49 as indicated below.

1. (ORIGINAL) A method of producing a hollow inorganic electrode for a solid oxide fuel cell, comprising:

(a) depositing electrode material onto an electrically conductive combustible core, the electrode material including electrically conductive metal, and ionically conductive ceramic particles, wherein at least the metal is deposited by electrodeposition;

(b) drying the core bearing the deposited electrode material; then,

(c) sintering the core bearing the deposited electrode material such that the core combusts, thereby producing a hollow electrode.

2. (ORIGINAL) The method of claim 1 wherein the ceramic particles are co-deposited with the metal on the core by composite electrodeposition, thereby forming a single-layered electrode.

3. (CURRENTLY AMENDED) The method of claim 1 wherein the metal is first deposited on the core by metal electrodeposition to form a metal layer, then the ceramic particles are deposited onto the metal layer by ~~one of composition electrodeposition or electrophoretic deposition~~, thereby producing a dual-layered electrode.

4. (ORIGINAL) The method of claim 1 wherein the electrode material includes combustible particles that are deposited onto the conductive core by electrodeposition, and are combusted during sintering, thereby producing a porous electrode.

5. (ORIGINAL) The method of claim 1 further comprising prior to deposition, applying masking material onto the combustible core, and after deposition, removing the masking material thereby leaving an electrode structure having openings corresponding to the masked areas, the openings being for the passage of reactant through the electrode.

Appl. No : 10/053241
Filed : January 16, 2002

6. (ORIGINAL) The method of claim 1 wherein the core is of a flexible material, and further comprising after electrodepositing and before sintering, manipulating the electrode into a suitable electrode shape.

7. (ORIGINAL) The method of claim 6 wherein the electrode is manipulated into one or a combination of shapes from the group of U-shaped, serpentine-shaped, or coiled shaped.

8. (ORIGINAL) The method of claim 1 wherein the electrode is an anode and the metal is one in the group of nickel, copper, palladium, chromium, platinum, gold silver and/or their alloys.

9. (ORIGINAL) The method of claim 1 further comprising after drying and before sintering, attaching a ceramic electrolyte to the outside surface of the electrode by electrophoretically depositing ceramic particles onto the electrode.

10. (ORIGINAL) The method of claim 9 wherein the ceramic electrolyte particles are yttria-stabilized zirconia.

11. (ORIGINAL) The method of claim 1 wherein the core is one of the group of a carbon fibre, a carbon fibre bundle, a carbon tow, or a carbon rod.

12. (ORIGINAL) The method of claim 4 wherein the porosity of the electrode is controlled by one or more of controlling the duration and temperature of the sintering step, controlling the particle size, size distribution and/or surface area of the combustible particles, controlling the thickness of the electrode, or controlling the sintering atmosphere.

13. (ORIGINAL) The method of claim 4 wherein the combustible particles are chosen from the group consisting of carbon, carbon black, and organic and polymeric compounds.

14. (ORIGINAL) The method of claim 10 wherein the electrophoretic deposition step is repeated before sintering to form an outer electrode on the electrolyte, the ceramic material for the outer electrode being electrically and ionically conductive.

15. (ORIGINAL) The method of claim 14 wherein the composition of the ceramic material of the electrolyte and outer electrode are the same, but one or more of the particle size, distribution, surface area, microstructure and porosity are different.

Appl. No : 10/053241
Filed : January 16, 2002

16. (ORIGINAL) A method of producing a hollow solid oxide fuel cell comprising

(a) producing an inner electrode by depositing inner electrode material onto an electrically conductive combustible core, the inner electrode material including electrically conductive metal, and ionically conductive ceramic particles, wherein at least the metal is deposited by electrodeposition;

(b) producing a ceramic electrolyte by electrophoretically depositing a ceramic material onto the outside surface of the inner electrode;

(c) drying the inner electrode and electrolyte;

(d) sintering the inner electrode and electrolyte under conditions sufficient to combust the core;

(e) producing an outer electrode by attaching outer electrode material onto the outside surface of the electrolyte, the outer electrode material including electrically and ionically conductive ceramic particles and combustible particles; and,

(f) sintering the inner electrode, electrolyte, and outer electrode under conditions sufficient to combust the combustible particles,

thereby producing a hollow fuel cell structure having a porous outer electrode.

17. (ORIGINAL) The method of claim 16 further comprising between steps (a) and (b), sintering the core-bearing the inner electrode under conditions sufficient to combust the core.

18. (ORIGINAL) A method of producing a hollow inorganic membrane, comprising:

(a) electrodepositing an inorganic material that includes electrically conductive metal onto an electrically conductive combustible core;

(b) drying the core bearing the deposited inorganic material; then,

(c) sintering the core bearing the deposited inorganic material such that the core combusts, thereby producing a hollow inorganic metal-containing membrane.

19. (ORIGINAL) The method of claim 18 wherein the material also includes ceramic particles that are co-deposited with the metal on the core by electrodeposition, thereby producing a hollow inorganic cermet membrane.

Appl. No : 10/053241
Filed : January 16, 2002

20. (ORIGINAL) The method of claim 18 wherein the material also includes combustible particles, and sintering the membrane also combusts the combustible particles, thereby producing a hollow porous inorganic membrane.

21. (ORIGINAL) The method of claim 18 further comprising after electrodepositing and before sintering, electrophoretically depositing ceramic particles onto the metal-containing membrane, thereby forming a multi-membrane hollow structure having an inner metal-containing membrane, and an outer ceramic membrane.

22. (ORIGINAL) The method of claim 21 wherein combustible particles are electrophoretically co-deposited with the ceramic particles onto the metal-containing membrane, and sintering the multi-membrane structure also combusts the electrophoretically deposited combustible particles, thereby producing a multi-membrane structure having a porous inner and outer membrane.

23. (ORIGINAL) The method of claim 18 wherein the core is of a flexible material, and further comprising after electrodepositing and before sintering, manipulating the membrane into a desired shape.

24. (ORIGINAL) The method of claim 23 wherein the electrode is manipulated into one or a combination of shapes from the group of U-shaped, serpentine-shaped, or coiled shaped.

25. (ORIGINAL) The method of claim 18 wherein the metal is one in the group of nickel, copper, palladium, chromium, platinum, gold silver and/or their alloys.

26. (ORIGINAL) The method of claim 18 wherein the ceramic particles are yttria-stabilized zirconia.

27. (ORIGINAL) The method of claim 18 wherein the core is one of the group of a carbon fibre, a carbon fibre bundle, a carbon tow, or a carbon rod.

28. (ORIGINAL) The method of claim 20 wherein the porosity of each membrane is controlled by one or more of controlling the duration and temperature of the sintering step, controlling the sintering atmosphere, controlling the particle size, size distribution and/or surface area of the combustible particles, or controlling the thickness of the membrane.

Appl. No : 10/053241
Filed : January 16, 2002

29. (ORIGINAL) The method of claim 20 wherein the combustible particles are chosen from the group consisting of carbon, carbon black, and organic and polymeric compounds.

30. (CURRENTLY AMENDED) A hollow solid oxide fuel cell comprising:

(a) an electrodeposition-formed inner electrode having a composition that includes an electrically conductive metal material and an ionically conductive ceramic material;

(b) a non-porous electrolyte electrophoretically deposited on the inner electrode and having a composition that includes ~~a~~an ionically conductive ceramic material; and,

(c) an outer electrode attached to the outer surface of the electrolyte and having a composition that includes an electrically ~~an~~and ionically conductive ceramic material.

31. (CANCELLED)

32. (CANCELLED)

33. (ORIGINAL) The fuel cell of claim 30 having one or a combination of a U-shape, serpentine shape, or helical shape.

34. (CANCELLED)

35. (CANCELLED)

36. (ORIGINAL) The fuel cell of claim 30 wherein the metal material of the inner electrode is one in the group of nickel, copper, palladium, chromium, platinum, gold silver and/or their alloys.

37. (ORIGINAL) The fuel cell of claim 30 wherein the ceramic material of the electrolyte is yittria-stabilized zirconia.

38. (ORIGINAL) The fuel cell of claim 30 wherein the ceramic material of the outer electrode is lanthanum strontium manganate.

39. (ORIGINAL) A hollow inorganic multi-layered membrane apparatus comprising:

(a) a hollow electrodeposition-formed inner membrane having a composition that includes a metal material; and,

Appl. No : 10/053241
Filed : January 16, 2002

(b) an outer membrane electrophoretically deposited on the inner membrane and having a composition that includes a ceramic material.

40. (CURRENTLY AMENDED) The apparatus of claim ~~33~~39 having one or a combination of a U-shape, serpentine shape, or helical shape.

41. (CURRENTLY AMENDED) The ~~fuel cell apparatus~~ of claim ~~36~~39 wherein the metal material of the inner membrane is one in the group of nickel, copper, palladium, chromium, platinum, gold silver and/or their alloys.

42. (CURRENTLY AMENDED) The ~~fuel cell apparatus~~ of claim ~~27~~39 wherein the ceramic material of the outer membrane is yttria-stabilized zirconia.

43. (NEW) The fuel cell of claim 30 wherein the inner electrode comprises a single cermet layer of the metal and ceramic materials.

44. (NEW) The fuel cell of claim 30 wherein the ceramic material of the inner electrode is also electronically conductive and the inner electrode comprises an inner metal layer and an outer ceramic layer attached to the outside of the inner metal layer.

45. (NEW) The fuel cell of claim 30 wherein the inner electrode comprises an inner metal layer and an outer cermet layer attached to the outside of the inner metal layer.

46. (NEW) A hollow solid oxide fuel cell comprising:

(a) an electrodeposition-formed inner electrode having a composition that includes an electrically conductive metal material and an ionically conductive ceramic material, and having a layer with a plurality of spaced reactant openings extending through the layer;

(b) a non-porous electrolyte electrophoretically deposited on the inner electrode and having a composition that includes an ionically conductive ceramic material; and

(c) an outer electrode attached to the outer surface of the electrolyte and having a composition that includes an electrically and ionically conductive ceramic material.

47. (NEW) The method of claim 3 wherein some of the metal is first deposited on the core by metal electrodeposition to form a metal layer, then some of the metal and the

Appl. No : **10/053241**
Filed : **January 16, 2002**

ceramic particles are deposited onto the metal layer by one of composite electrodeposition or electrophoretic deposition, thereby producing a dual-layered electrode.

48. (NEW) The method of claim 16 wherein the metal is first deposited on the core by metal electrodeposition to form a metal layer, then the ceramic particles are deposited onto the metal layer by electrophoretic deposition, thereby producing a dual-layered electrode.

49. (NEW) The method of claim 16 wherein some of the metal is first deposited on the core by metal electrodeposition to form a metal layer, then some of the metal and the ceramic particles are deposited onto the metal layer by one of composite electrodeposition or electrophoretic deposition, thereby producing a dual-layered electrode.